PROCEEDINGS OF

THE ROYAL SOCIETY.

Section A.—Mathematical and Physical Sciences.

Address delivered by the President, Sir William Huggins, K.C.B., O.M., F.R.S., at the Anniversary Meeting on November 30th, 1904.

Since the last Anniversary the Society has lost by death fourteen Fellows. The deceased Fellows are :—

Sir Frederick Bramwell, born 1818, died Nov. 30, 1903.
Robert Etheridge, born Dec. 3, 1819, died Dec. 18, 1903.
George Salmon, born Sept. 25, 1819, died Jan. 22, 1904.
Lieut.-General C. A. McMahon, born March 23, 1830, died Feb. 21, 1904.
Sir C. Le Neve Foster, born Mar. 23, 1841, died April 19, 1904.
George Johnston Allman, born 1824, died May 8, 1904.
Alexander William Williamson, born May 7, 1824, died May 6, 1904.
Robert McLachlan, born April 10, 1837, died May 23, 1904.
Isaac Roberts, born 1829, died July 17, 1904.
Sir John Simon, born Oct. 10, 1816, died July 23, 1904.
Joseph David Everett, born 1831, died Aug. 9, 1904.
Sir William Vernon Harcourt, born Oct. 14, 1827, died Oct. 1, 1904.
Frank McClean, born 1837, died Nov. 8, 1904.
Earl of Northbrook, born 1826, died Nov. 15, 1904.

Memorial Notices of the Fellows who have been taken from us by death during the past year will appear in due course in the Obituary Notices.

Of some of them only, on this occasion, will time permit me to give expression, on your behalf, to a few words of appreciation of their work, and of deep sorrow at their loss.

In your name I place a wreath, emblem of our respect and of our deep sorrow, to the memory of our late Fellow and Copley-Medallist, the revered Provost of Trinity College, Dublin, who passed away at the ripe age of eighty-four years. George Salmon was as remarkable in the influence of his powerful personality, as in his works, by which he extended and adorned two domains of thought, as diverse as mathematics and theology. It is given to few men to achieve a European reputation as an investigator of the first rank in two distinct provinces of knowledge.

Born and educated in the City of Cork, he matriculated at Trinity College, Dublin, at the early age of fourteen. After a brilliant undergraduate course, he took his degree in 1838, and was elected a Fellow in 1841. Devoting himself to the study of pure mathematics, he produced a series of books, now accounted as classics in every university of the world, which were of very great service in promoting the advancement of that science. Their value was shown by the number of their editions, by their translation into several languages, and by the honours they procured for their author. In his "Lessons Introductory to the Study of the Modern Higher Algebra," which grew in subsequent editions until it became a treatise, he made accessible to the student the recent researches of the previous twenty years into the theory of transformations of binary forms.

Following the traditions of the Dublin School of Mathematics, he gave wide scope in all his books to geometrical method, often relieving the monotony of pages of analysis by the introduction of a brilliant geometrical proof.

In 1866, on the preferment of Dr. Butcher, Salmon was appointed Regius Professor of Divinity, from which time he ceased to work at mathematics, except in an occasional way at the Theory of Numbers. This is not the place for a consideration of his contributions to theological literature, nor of his great influence in the Church in Ireland at a time of exceptional difficulty. One important aspect of his theological labours is expressed by the title which was given to him of "*malleus Germanorum*."

In the year 1888 he was appointed by the Lord Lieutenant to the post of Provost of Trinity College. His large sympathy with all sorts and conditions of men, his unaffected dignity, his genial humour, and his kind heart, gave to his masterful tenure of the office of Provost an influence probably unparalleled in the history of Trinity College.

Not Trinity College alone, but all Dublin was proud of him. Men of all classes and creeds praised him. His private tastes were simple; his chief relaxations, chess playing, music, and novel reading. In the words of the late Bishop of Oxford:—"The Provost is an extraordinary man. The first day I met him I was most struck by his gracious courtesy, the second day by his learning, the third day by his humour, and every day by his humility."

The Fates are inexorable; there may be long delay, but always at last the thread is cut. In midsummer our oldest Fellow, in point of election as well as of age, passed from us:—Sir John Simon, the pioneer of modern sanitary science. What Lister did for surgery, and Pasteur for bacteriology, Simon may be said to have accomplished for sanitation. Very early he perceived clearly and developed the true nature and mode of dealing with contagious emanations proceeding from the sick, establishing a doctrine and practice which afterwards received their direct proof and further development in the growth of the new science of bacteriology. Deeply grateful to his memory, we mourn one who by his life-work conferred incalculable benefit upon the whole civilized world.

Simon commenced the study of medicine in 1833, and attended both St. Thomas's Hospital and the recently established King's College. It was in 1848 that his attention was definitely directed to that branch of the profession with which his name will always remain famous, and which indeed he may almost be said to have founded, through his election to the newly-constituted post of Medical Officer of Health to the City of London. Seven years later a Central Board of Health was created, on which Simon represented medicine. When the functions of the Board were transferred to the Privy Council, he became adviser to the Government on all sanitary and medical matters. It is not possible on this occasion to indicate, even broadly, his strenuous work through a long life for the public good. His writings consist mainly of his numerous official reports, together with a volume published in 1857, entitled "Papers on the History and Practice of Vaccination," followed in the next year by a "Report on the Sanitary State of the People of England," which brought out for the first time the wide variations which exist in the local incidence of diseases. His great work on "English Sanitary Institutions" appeared in 1890. In 1878 he was elected President of the Royal College of Surgeons; he was the recipient of numerous honours from scientific bodies at home and abroad. At the Jubilee in 1887 he received from Queen Victoria the distinction of K.C.B. These public recognitions were the outward signs of the universal respect and honour accorded him by all men. His memory will ever remain green in the history of sanitary science.

In May passed away, full of years and full of honours, a Fellow to whose personal services the Society is largely indebted—Professor Williamson. Elected into the Society in 1855, after serving twice upon the Council, he became Foreign Secretary in 1873, which office he held for sixteen years, until 1889. Half a century ago Williamson took a prominent part in the development of chemical thought, and exercised a powerful influence on chemical teaching in this country. He began the study of chemistry at Heidelberg, but soon passed to Liebig's laboratory at Giessen, where he took his degree, and while there published papers on the decomposition of Oxides and Salts by Chlorine, and on "The Blue Compounds of Cyanogen and Iron." He then went to Paris, where he came under the teaching of Comte. In 1849 he left Paris to occupy the chair of practical chemistry in University College, from which he continued to teach for thirty-eight years. A little later he published the classical research, elucidating the process of the formation of ether, with which his name will always remain associated. This paper, a model of concise reasoning founded upon happily devised experiment, produced a profound influence on contemporary thought, and received the assent of the whole chemical world. In this paper he gave his acceptance of the doctrine of types, which was prominent in his subsequent teaching. Williamson was a pioneer of chemical thought in quite another direction by the introduction of the conception of dynamics into chemical processes. He advanced the view, which is fundamental in the modern hypothesis of ionic dissociation, that in substances which appear at rest, the atoms of the molecules of the compound are in motion, exchanging from one molecule to another in an unending course of ionic migrations.

Williamson occupied the chair of the British Association in 1873, and was twice President of the Chemical Society. Honorary degrees were conferred upon him by the Universities of Dublin, Edinburgh, and Durham, and he received the honorary membership of many scientific societies. Seventeen years ago he retired from professional life to Hindhead.

Alas! this room will know no more a frequent and welcome attendant at our meetings who often took part in our discussions. A man whose great natural vitality and intellectual activity were so remarkable and unimpaired, that his sudden death came as a great shock to his many friends. Professor Everett was born and educated at Ipswich, and after graduating with honours at Glasgow, he became Professor of Mathematics at King's College, Nova Scotia. Later, in 1867, he was appointed Professor of Natural Philosophy at Queen's College, Belfast, a chair which he occupied with distinction for thirty years. Since his retirement, about seven years ago, he has resided in London, taking an active part in the proceedings of scientific societies, especially of the Physical Society, of which he was a Vice-President. Professor Everett rendered important service to physical science, by his admirable translation of Deschanel's "Treatise of Natural Philosophy," which he brought up to date from time to time by the necessary additions and alterations, and by his "Illustrations of the C.G.S. System," which was translated into several languages, and proved of material service in the establishment of a physical system of units. He did important work as the secretary of the Committee of the British Association which effected the selection and naming of these dynamical and electrical units, and also of the Committee which has collected our main knowledge of underground temperatures. He was the inventor of a system of shorthand, which provides greater facilities for vowel insertion than other systems. He was enthusiastically devoted to cycling. A man of great kindliness and geniality, he is regretted by a large circle of friends, and will always be remembered by his numerous pupils with much gratitude and affection.

Death has deprived us of a Fellow whose genial humour, clear judgment, and ready wit endeared him to many friends—Sir Frederick Bramwell. In Bramwell the love of things mechanical was inborn. At the time of his youth, technical education was all but unknown, and very few engineering students could take advantage of such a meagre scientific education as was then available. He was a striking example of what he himself said of some distinguished engineers :—"That they literally became such because they could not help it." With Bramwell the taste for engineering was innate and supreme. Study was not congenial to him; his extensive and varied knowledge was mainly the outcome of personal observation and experience.

After some years' varied experience in different engineering workshops he commenced practice on his own account in 1853. He soon made his mark; but, as he especially shone in debate, where his judgment was rarely at fault, and he brought shrewd common sense to bear with happy flashes of wit and apt practical illustrations, he was irresistibly drawn from the constructive to the legal side of his profession, in which he received no little advantage from his powerful voice and his commanding presence. In giving evidence, Bramwell was remarkably able, and as an arbitrator his judgments were clear, judicial, and marked by legal acumen. In one or other capacity his services were in much demand during the last thirty or forty years. He was chosen President of the Institution of Mechanical Engineers in 1874, and, ten years later, President of the Institution of Civil Engineers. He was President of the British Association at its meeting at Bath in 1888. He became one of our Fellows in 1873, and served on the Council in 1877-1878. On the retirement of Sir William Bowman, he was elected Honorary Secretary of the Royal Institution. Honorary degrees were conferred upon him by the Universities of Oxford, Cambridge, Durham, aud Montreal. In 1889 Queen Victoria bestowed upon him the honour of a baronetcy.

George Johnston Allman was born in Dublin in 1824. He entered Trinity College at an early age, and at the honour degree examination, in 1843, he obtained Senior Moderatorship and a gold medal in mathematics. A few years later he was elected to the Professorship of Mathematics in Queen's College, Galway, a post which he held for nearly forty years, until his retirement in accordance with the age limit. His most important works were a paper, "On some Properties of the Paraboloids," and a series of papers on the history of Greek mathematics, which formed the basis of his celebrated book "Greek Geometry from Thales to Euclid." He was elected a Fellow of the Society in 1884.

The name of Dr. Isaac Roberts will always be associated with the photography of the heavenly bodies. He early showed his love for physical science. His first scientific paper was on the wells and water of Liverpool, where he resided; and in the following year, 1870, he was elected a Fellow of the Geological Society. Other papers followed on underground waters, especially with respect to their oscillations in porous strata. He soon directed his principal attention to Astronomy, and erected an observatory near Liverpool. At first he contemplated photographing the whole northern heavens, but when an astrographic chart and catalogue for both hemispheres were undertaken by an international co-operation of Observatories, with great prescience he decided to devote himself to photographing star-clusters and nebulæ. Finding the neighbourhood of Liverpool unfavourable for such work, after a long personal examination of various sites, he erected an observatory on Crowborough Hill, where, during thirteen years, he secured the splendid series of astronomical photographs, bringing to light a wealth of unsuspected detail, which have largely aided in the recent extension of our knowledge of nebulæ and star-clusters. Two volumes containing reproductions of these photographs were published by Dr. Roberts at his own expense, and widely distributed among astronomers. He was elected to our Fellowship in 1890. In 1892 Trinity College, Dublin, conferred upon him the honorary degree of D.Sc.; three years later he received the gold medal of the Royal Astronomical Society.

To his many friends the sudden death of Sir Clement le Neve Foster came as a very painful shock. He was educated in France, and obtained the degree of Bachelor of Science of the University of France at the early age of sixteen. He then entered the Royal School of Mines, where in two years he achieved the remarkable distinction of securing the Associateship in the Mining, Metallurgical, and Geological divisions, as well as the Duke of Cornwall's Scholarship and the Forbes Medal. In 1872 he was appointed H.M. Inspector of Mines. He succeeded, in 1890, Sir Warrington Smyth as Professor of Mining at the Royal College of Science, and the Royal School of Mines. He became a Fellow of our Society in 1892. On the King's birthday, last year, he received the honour of Knighthood. During his twenty-nine years' Government Inspectorship, Sir Clement did much to ameliorate the lot of the miner, and to establish metal mining on a scientific basis.

Quite recently the Society has suffered a further loss in the unexpected death of Dr. McClean, who, by his wisely considered benefactions, as well as by his personal work, has contributed not a little to the increase of natural knowledge. Having retired thirty-four years ago from professional work as an engineer, he built an astronomical observatory at his house at Tunbridge Wells, and devoted himself to photo-spectroscopic work on the sun and stars. His photographic spectra of all stars above the $3\frac{1}{2}$ magnitude appeared in our *Transactions*, in which he showed the presence of oxygen in connection with helium in certain stars. His benefactions to Science are of two kinds. In 1890 he founded the Isaac Newton Studentships at Cambridge for the promotion of the study of Astronomy and Astronomical Physics; while, on the practical side, ten years later, he made a most generous gift of valuable instruments to the Royal Observatory at the Cape of Good Hope. He has crossed the great bar, to the deep sorrow of his many friends, and to the great regret of all men of science.

During the last few years a very large amount, increasing each year, of work outside the reading, discussion, and printing of papers, of a more or less public character, has been thrown upon the Royal Society—so large indeed as at present to tax the Society's powers to the utmost. A not inconsiderable part of this work has come from the initiation by the Society itself of new undertakings, but mainly it has consisted of assistance freely given, at their request, to different Departments of the Government on questions which require expert scientific knowledge, and which involves no small amount of labour on the part of the Officers and Staff, and much free sacrifice of time and energy from Fellows, in most cases living at a distance.

There is little doubt that this largely-increased amount of public work has arisen, in part naturally from the greater scientific activity of the present day, but also, and to a greater extent, from the fuller recognition by the Government and the public of the need for scientific advice and direction in connection with many matters of national concern.

It may not be inopportune, therefore, for me to say a few words on the advisory relation in which the Society has come to stand to the Government, and to review very briefly the great work which the Society has done, and is doing, for the Nation.

Among Academies and Learned Societies the position of the Royal Society is, in some respects, an exceptional one. In the British dominions it holds a unique position, not only as the earliest chartered scientific Society, but in its own right, on account of the number of eminent men included in its Fellowship, and the close connection in which it stands, though remaining a private institution, with the Government. The Royal Society is a private learned body, consisting of a voluntary and independent association of students of Science united for the promotion of Natural Knowledge at their own cost. It asks for no endowment from the State, for it could not tolerate the control from without which follows the acceptance of public money, nor permit of that interference with its internal affairs which, as is seen in some foreign academies, is associated with State endowment. In one particular case, in which it can receive aid without any loss of independence, the Society gratefully acknowledges its indebtedness to the State. About 1780 the Society received a communication from the Government offering to provide apartments for the Society at Somerset House; these were exchanged, in 1857, for rooms in old Burlington House; after its rebuilding, in 1873, the Society moved into the apartments which it now occupies. It should not be forgotten that nearly a century before the opening of the British Museum in 1759, the Royal Society's Museum, or Repository as it was called, enjoyed the prestige of being regarded as the most important Museum in London, and must have been of great use to men of science, and have aided materially in promoting and disseminating the knowledge of natural history. The apartments offered to the Society at Somerset House were quite insufficient in capacity and in number to receive the Society's Museum, and in consequence, this collection, which had been carefully maintained not only from the scientific side, but also with reference to the commercial value and importance of the foreign objects received, especially of the valuable zoological specimens frequently sent by the Hudson's Bay Company from their territories, was presented by the Society to the Nation, a not unworthy acknowledgment, on the Society's part, of the Government's gift of apartments. This collection has not been kept separate, but is now hopelessly dispersed among the thousands of specimens which crowd the halls of our National Museum. Some specimens, however, in comparative anatomy, preserved in the Museum of the College of Surgeons, are duly entered in the catalogue as having belonged originally to the Royal Society's Museum.

Besides the grant of apartments in Somerset House, and subsequently in Burlington House, the Society has received no pecuniary support from Government, nor assistance of any kind, with one exception to be mentioned further on, beyond the grant by Charles II. shortly after its incorporation, of Chelsea College and the lands appertaining to it; a gift which proved much less valuable than appeared from the parchments. Claimants at once came forward for portions of the estate, and the property was in so unsettled a state as to title, and so much out of repair, that after much money had been spent on repairing the College and great exertions made in vain to procure a tenant, the President was authorised to sell the estate to the King for the sum of £1,300; the Council voting their thanks to him for "thus disposing of a property which was a source of continual annoyance and trouble to them." To the extent of this sum the Society's funds were enriched by the royal gift.

The grants of £4,000 and £1,000 now received annually by the Royal Society from the Government are not applicable to its own needs, but are placed in its hands in trust for grants in aid of the prosecution of scientific research, and of the publication of scientific papers; indeed, with the exception of part of the publication grant, are so far from being of the nature of a State bounty, that the careful administration of these grants brings no light burden upon the Society.

It may not be generally known that the Royal Society just missed becoming a richly-endowed Society. Charles II.'s interest in the young Society did not end with the grant of a Charter of Incorporation, for in 1662 he addressed a letter, written with his own hand, to the Duke of Ormonde, then Lord Lieutenant of Ireland, recommending the Royal Society for a "liberal contribution from the adventurers and officers of Ireland for the better encouragement of them in their designs." That is to say, in the new settlement in that country, on the Restoration, of the confiscated estates of such persons as by the King's declaration were disqualified. The Royal Society had but a poor chance, notwithstanding the King's letter, of coming in for a portion of these so-called "fractions," when so many high families were cheated of their rights, and the Duke's own estates, through his methods of adjudication, increased from £7,000 to £80,000 per annum. Sir

William Petty, in a document preserved in the archives of the Society, estimates the value of the lands granted by the King to the Society, but not received by them, "as a great matter, but I know not what."

It is on record that the non-fulfilment of the King's generous intentions towards the Society did not damp the philosophic ardour of the Fellows; indeed, it is a question on which opinions may widely differ whether the rich endowment of the Society, almost from its very birth, would have increased its scientific success. We must not forget that, in the case of institutions as well as of individuals, the powerful and healthy stimulus to the exertion needful for success which arises from the necessity of coping with and overcoming difficulties, whether of a monetary or other kind. In no small degree was due to the personal favour with which Charles II. regarded the Society, the exceptional position it early took up, and which it still holds to-day, of a private institution supported and controlled from within, which, at the same time, is acknowledged by the State as the authoritative national representative of Science in this country, and from time to time consulted as such.

The first royal act which distinctly gave this representative character to the newly chartered Society appears to have been the King's declaring his pleasure on the 15th October, 1662, "that no patent should pass for any philosophical or mechanical invention until examined by the Society." This personal recognition by the King of the national position of the Society was followed and confirmed a few years later by a request from the department of the Admiralty for assistance from the Royal Society in raising some ships sunk off Woolwich. The Council replied that, though they would have great pleasure in affording all assistance in their power by advice, the want of funds rendered it impossible for them to provide the necessary machinery.

From that time down to the present the Royal Society, while remaining a purely private institution for the promotion of Natural Knowledge, has been regarded by the Government as the acknowledged national scientific body, whose advice is of the highest authority on all scientific questions, and the more to be trusted on account of the Society's financial independence; a body, which, through its intimate relations with the learned societies of the Colonies, has now become the centre of British Science. The Society's historical position and the scientific eminence of its Fellows have made it naturally the body which the scientific authorities of foreign countries regard as representing the Science of the Empire, and with which they are anxious to consult and to co-operate, from time to time, on scientific questions of international importance.

On their part, the Fellows of the Royal Society, remembering that the promotion of Natural Knowledge is the great object for which it was founded and still exists, and that all undertakings in the home and in the State, since they are concerned with Nature, can be wisely directed and carried on with the highest efficiency only as they are based upon a knowledge of Nature, have always recognised the fundamental importance of the Society's work to national as well as to individual success and prosperity, and their own responsibility as the depositories of such knowledge. They have always been willing, even at great personal cost, ungrudgingly to afford any assistance in their power to the Government on all questions referred to them which depend upon technical knowledge, or which require the employment of scientific methods. In particular the Society has naturally always been eager to help forward, and even to initiate, such national undertakings as voyages of observation or of discovery of any kind, or for the investigation of the incidence of disease, which have for their express object the increase of Natural Knowledge.

At the same time, as the Society is dependent upon the voluntary help of its Fellows, whose time is fully occupied with their own work, the Society may reasonably expect the Government not to ask for assistance on any matters of mere administration that could be otherwise efficiently provided for. The hope may be expressed that in the near future, with increased official provision in connection with the recognition of Science, the relation of the Society to the Government may not extend beyond that of a purely advisory body, so that the heavy responsibilities now resting upon it, in respect of the carrying out of many public undertakings on which its advice has been asked, may no longer press unduly, as they certainly do at present, upon the time and energy of the Officers and Members of Committees. The Society regards this outside work, important as it is, as extraneous, and therefore as subordinate, and would not be justified in permitting such work to interfere with the strict prosecution of pure natural science as the primary purpose of the Society's existence, upon which, indeed, the Society's importance as an advisory body ultimately depends.

The array of national undertakings of which the Society has been wholly or in part in charge, or to which it has given advice or assistance from time to time, is so very great that any attempt to point out, even in broad outline, the more important of the directions in which the Society's influence has been actively employed for the public service, must necessarily be fragmentary and very incomplete. On this occasion it is not possible to do more than to give, in a few sentences, a rapid presentation of a few typical examples of the Society's public work.

It must be borne in mind that the bare statement in a few sentences of the public work accomplished by the Society fails altogether to bring before the imagination an adequate conception of the large amount of free labour ungrudgingly given by those Fellows who composed the several committees to which the work was entrusted.

Going back to the first century of the Society's existence, the work done for the National Observatory at Greenwich may be fairly taken as typical of the Society's outside activity at that time. It is not too much to say that the Observatory owes, in no small degree, its early efficiency and the high position it soon reached, to the advice and the energetic action on its behalf of the Royal Society. The Observatory, at the time it was placed, in 1710, by Queen Anne in the sole charge of the Society, was without instruments, except such as Flamsteed had himself supplied. Immediately on taking charge, the Society appointed a Committee which visited Greenwich, and, as a result, sent in an application to the Ordnance Office, but at the time unsuccessfully, for the new instruments which were absolutely essential for properly carrying on the work of an observatory. The little interest taken by the Government of that day in Science is manifest from the answer received from the Ordnance Office, "that they had never been at any charge for instruments, but only for repairing the house and paying Mr. Flamsteed's salary." The Society persevered, and when, in 1720, Halley succeeded Flamsteed, was successful in persuading the Government to provide a few of the more necessary instruments. At a little later date the Society induced the Government to expend £1,000 on instruments, to be constructed by Graham and Bird. When George III. came to the throne he re-appointed the Society as sole visitors, and ordered the Astronomer Royal to obey the regulations drawn up by the Council, and commanded the Master General of Ordnance to furnish such instruments as the Council should think necessary for the Observatory. In the list of these instruments is mentioned a ten-foot telescope of Dollond's "new invention." Further, it was in answer to a petition from the Royal Society that the King gave orders for the printing of the Observations made at the Observatory. At a later date the Society called on the Government to advance funds to establish magnetical observatories at Greenwich, and in various parts of the British dominions, with the result that in a few years no fewer than forty magnetical establishments were in full activity.

In connection with the Observatory may be mentioned the considerable share which the Society took in bringing about the important alteration of the Calendar, known as the Change of Style, which took place in 1752. The

Bill was drawn up by Peter Davall, the Secretary of the Society, aided and supported by Lord Macclesfield, who became President the same year. The change was approved and assisted by the actual President, Martin Folkes. The feeling of the people was so strongly against the change that the illness and death of Bradley, who as Astronomer Royal had assisted the Government with his advice, which took place not long afterwards, were popularly attributed to a judgment from Heaven.

Very brief must be the mention of some of the other works in the public service which were carried out at a no small cost of labour to the Fellows of the Society.

About 1750, the Lord Mayor of London, two of the Judges and an Alderman, having died in one year from jail-fever caught at the Old Bailey Sessions, the Society was called upon for advice and assistance. A committee was appointed to investigate the wretched state of ventilation in jails. A ventilator, invented by one of the committee, was erected in Newgate, reducing at once the number of deaths from eight a week to about two a month. Of the eleven workmen employed to put up the ventilator, seven caught the fever and died.

At the request of the Government, committees were appointed to consider the best form of protection of buildings, and, later on, of ships at sea, from lightning.

The Society took a very active part in the measurement of a degree of latitude, afterwards in the length of a pendulum vibrating seconds in the latitude of London, and in the comparison of the British Standards with the Linear Measure adopted in France. A committee was appointed to compare the Society's Standard yard with that of the Exchequer. Later, in 1834, when the Standard yard was lost in the destruction by fire of the Houses of Parliament, a Commission (all the members of which were Fellows of the Royal Society) was appointed to consider the steps to be taken for the restoration of the Standards.

It was at the instance of the Council of the Society, who petitioned George III. for the necessary funds, that the King gave his consent to a geodetical survey in 1784, with the immediate object of establishing a trigonometrical connection between the Observatories of Greenwich and Paris. The work, under General Roy, for which the Copley Medal was awarded to him, served as a basis for the operations of a more extensive nature, embracing a survey of the British Islands, which were commenced in 1791.

Since its foundation the Society has taken an active part in many important expeditions for scientific and geographical exploration, and for magnetical and astronomical observations, in some cases taking the initiative by memoralizing the Government for the necessary assistance by grants of money, the use of ships, or otherwise. Among these may be mentioned the expeditions sent out for the observation of the Transits of Venus in 1761, and in 1769.

The importance of Antarctic exploration, for which the recent National Expedition has recently been promoted jointly with the Royal Geographical Society, was fully understood by the Royal Society nearly a century and a half ago. In 1771, an expedition having for its principal object the exploring of high southern latitudes with the view of ascertaining the existence of a great Antarctic Continent, was strongly and successfully urged on the Government by the Society. The expedition under Captain Cook sailed the following year. On its return three years later, after having circumnavigated the globe, the Copley Medal was awarded to Captain Cook for the means he had taken to preserve the health of his crew.

In 1817, a letter was addressed by Sir Joseph Banks, on the part of the Council, to Lord Melville urging that an expedition of discovery should be sent out for determining the practicability of a North-West Passage. The Lords of the Admiralty gave orders for the fitting out of four vessels, and invited detailed instructions from the Royal Society for the guidance of the officers. The Council recommended Colonel, then Captain, Sabine to proceed with the North-West Expedition, and Mr. Fisher to accompany the Polar one. The expedition failed to procure geographical results of importance, but it was far from fruitless, for the magnetical observations brought back by Sabine were an addition of real value to physical science.

This expedition was followed by another two years later under Parry, which resulted in the discovery of the Strait called after Barrow, then Secretary to the Admiralty.

A later Polar Expedition, under Captains Parry and Ross in 1827, was promoted by the Royal Society, and brought home valuable magnetical observations, which were printed in the Society's Transactions.

At home, it was through the Society's influence that Dr. Maskelyne, the Astronomer Royal, was able to make observations in Scotland for the purpose of deducing the density of the earth. Dr. Hutton undertook the laborious task of working up the data, the whole expenses being borne by the Society.

These few examples, inadequate as they are, must suffice on this occasion to remind us of the many labours during two centuries and a half undertaken by the Society for the public good. I pass now at once to some of the many objects of public concern, which are at the present time either directly promoted, or assisted by the Society.

The establishment in this country of a National Physical Laboratory for the purpose of bringing scientific knowledge to bear practically upon the industries and commerce of the nation, was due in no small measure to the action of the Society, and has certainly thrown upon it much additional permanent responsibility. The necessity for such an Institution in this country, which was clearly shown by the marked influence of a similar Institution on the improvement of technical science and the manufacturing interests of Germany, had been already strongly advocated by individual Fellows; in particular, by Sir Oliver Lodge at Cardiff in 1891, and Sir Douglas Galton at Ipswich five years later; but the first practical step towards its realisation was taken by the Council in 1896, when they decided that the Royal Society should join the British Association and other kindred Societies in a Joint Committee, under the Chairmanship of the President of the Royal Society, to take such action as they find desirable.

In the following year, this Committee waited upon Lord Salisbury, who was then Prime Minister, and, as a result, a Treasury Committee was appointed by the Chancellor of the Exchequer, with Lord Rayleigh as Chairman, to consider the desirability of establishing a National Laboratory. That Committee, after hearing witnesses and visiting Germany, reported strongly and unanimously in favour of such a national Institution. In 1898, a communication was received from the Treasury expressing "the hope that the Royal Society will be willing to add to the already great services rendered by them to the Government and public of the United Kingdom, by consenting to undertake the new responsibilities now sought to be imposed upon them" in connection with the new Institution. The Council accepted the important trust, under which the "ultimate control of the Institution is vested in the President and Council of the Royal Society, who in the exercise thereof may issue from time to time such directions as they may think fit to the General Board and Executive Committee." The income and all other property is vested in the Royal Society for the purposes of the Institution. The Laboratory, which was formally opened by H.R.H. the Prince of Wales in March, 1902, has already made remarkable progress under its energetic Director. During the present year the attention of the Prime Minister has been called to the very great importance to the national industries of an immediate grant for new buildings and a more adequate instrumental equipment, and of a larger annual endowment.

It is not too much to say that men of Science of all countries are under no small obligation to the Royal Society for their Catalogue of Scientific Papers which have appeared in all parts of the world since the beginning of the last century. This great work, to which immense labour has been given gratuitously and without stint by Fellows during the past forty years, will be carried down to the close of the century, and will consist of two parts: an Authors' Catalogue, and a Catalogue of Subjects. Encouraged by a donation from Mr. Andrew Carnegie, and the noble liberality of Dr. Ludwig Mond and other Fellows, the Council decided to proceed with the completion of the Catalogue, in the hope of further donations from Fellows and others as the work advances.

It was obvious that to continue permanently to prepare and publish catalogues of the rapidly increasing output of scientific literature would be wholly beyond the means of any one Society, and was an undertaking so vast as to require organized international co-operation for success. In 1893, a letter, signed by seventeen Fellows, was addressed to the President, asking that steps might be taken to provide for the continuation of the Society's Catalogue from the beginning of the century by adequate international co-operation. A Committee was appointed, which reported in favour of an international conference on the subject. Three conferences were held successively in 1896, 1898, and 1900. It is scarcely possible to convey an adequate conception of the arduous and prolonged labours of these conferences, and of the numerous meetings of committees held in connection with them. The Society may well feel great satisfaction that a work of such magnitude, and of so great moment to all scientific workers, which was initiated by itself, was taken up with such remarkable accord by the scientific world. The organization consists mainly of a Central Bureau in London under the Royal Society, in connection with Regional Bureaus, established in thirty countries for collecting material in the form of catalogue slips, and transmitting them to the Central Bureau. The Royal Society has taken upon itself practically the financial responsibility of the undertaking, making contracts in its own name with a printer and a publisher, the latter undertaking the technical duties as agent for the Society, which is its own publisher. The first year's issue of the catalogue has appeared, dealing in twenty-one volumes with the seventeen sciences decided upon by the conference.

The International Association of Academies, the realization for the first time of the great scientific idea of a Universal Academy, open without restriction of language or of country to every nation under heaven, owes its establishment to the initiative of the Royal Society. In 1897, the Royal Society was invited to send representatives to a Conference of a Union of German Academies and Societies which met from time to time. The Society sent delegates, but declared that the Society's permanent adhesion to any such association must be conditional on its being made truly international in character. The principle of an international association of learned Societies suggested by the Royal Society, was accepted, and a Conference was held at Wiesbaden in 1899 for the purpose of taking steps for the formation of such an association. Statutes were drawn up and arrangements made for the holding of the first General Assembly in Paris in 1901.

The primary objects of the Association are the initiation and promotion of scientific undertakings of general interest and of universal concern to mankind, especially of such matters as are outside the power of a single Academy and require for their promotion the assistance of the Governments represented by the Association. Indirectly by its triennial General Assemblies in different countries, it should become an instrument of no mean power for the promotion of the brotherhood of mankind and for hastening the day

> "When the war drums throb no longer and the battle flags are furl'd,
> In the Parliament of man, the Federation of the world."

The Association, as now constituted, consists of twenty Academies and learned Societies of Europe and America. The second General Assembly of the Association was held this year in London under the auspices of the Royal Society, which, as directing Academy, had had general charge of the conduct of its business during the last three years. The Section of Letters met under the direction of the newly-founded British Academy.

The Society has accepted heavy responsibilities at the instance of the Government in respect of the control of scientific observations and research in our vast Indian Empire. In 1899, the India Office inquired whether the Royal Society would be willing to meet the wishes of the Indian Government by exercising a general control over the scientific researches which it might be thought desirable to institute in that country. A Standing Committee was appointed in consequence by the Council for the purpose of giving advice on matters connected with scientific enquiry, probably mainly biological, in India, which should be supplementary to the Standing Observatories Committee which was already established at the request of the Government as an advisory body on astronomical, solar, magnetic, and meteorological observations in that part of the Empire.

An investigation, onerous indeed, but of the highest scientific interest and of very great practical importance, has been carried on by a series of Committees successively appointed at the request of the Government for the consideration of some of the strangely mysterious and deadly diseases of tropical countries. In 1896 a Committee was appointed at the request of the Colonial Secretary to investigate the subject of the Tsetse Fly disease in South Africa. Two years later Mr. Chamberlain, Secretary of State for the Colonies, requested the Society to appoint a Committee to make a thorough investigation into the origin, the transmission, and the possible preventives and remedies of tropical diseases, and especially of the malarial and "Blackwater" fevers prevalent in Africa, promising assistance, both on the part of the Colonial Office and of the Colonies concerned. A Committee was appointed, and, under its auspices, skilled investigators were sent out to Africa and to India. In the case of the third Committee the Society itself took the initiative. An outbreak in Uganda of the disease, appalling in its inexorable deadliness, known as "Sleeping Sickness" having been brought to the knowledge of the Society, a deputation waited upon Lord Lansdowne at the Foreign Office, asking him to consider favourably the despatch of a small Commission to Uganda to investigate the disease. He gave his approval, and a Commission of three experts, appointed on the recommendation of the Committee, was sent out to Uganda, £600 being voted out of the Government Grant towards the expenses of the Commission.

The investigations in tropical diseases, promoted and directed by these Committees, have largely increased our knowledge of the true nature of these diseases, and, what is of the highest practical importance, they have shown that their propagation depends upon conditions which it is in the power of man so far to modify, or guard against, as to afford a reasonable expectation that it may be possible for Europeans to live and carry on their work in parts of the earth where hitherto the sacrifice of health, and even of life, has been fearfully great. A general summary of the work already done on Malaria, especially in regard to its prevention, and also on the nature of "Blackwater" Fever, has been published in a Parliamentary paper, which records Mr. Chamberlain's acknowledgment to the Royal Society for its co-operation in the work undertaken by the Colonial Office. Our Reports on Sleeping Sickness up to this time form four parts of a separate publication giving evidence in support of the view that this deadly disease is caused by the entrance into the blood, and thence into the cerebro-spinal fluid, of a species of Trypanosoma, and that these organisms are transmitted from the sick to the healthy by a kind of tsetse fly, and by it alone; Sleeping Sickness is in short, a human tsetse fly disease.

In 1897, the Council was requested to assist the Board of Trade in drawing up Schedules for the establishment of the relations between the Metric and the Imperial Units of Weights and Measures. A Committee was appointed, which, after devoting much time and attention to the matter, drew up Schedules which were accepted by the Board of Trade and incorporated in the Orders of Council.

A Coral Reef Committee has been in active existence for some years, and has directed the attempts to pierce, by boring, the atoll of Funafuti, towards the expenses of which grants have been made by the Council. The results of the work have appeared in a large volume, giving a description of the whole core from the points of view of the naturalist and the chemist; and a list, with critical remarks, of the species of animals and plants collected.

Soon after the reports were received of the appalling volcanic eruptions and the loss of life which took place in the West Indies in 1902, the Council received a letter from Mr. Chamberlain to ask if the Society would be willing to undertake an investigation of the phenomena connected with the eruptions. The Council, considering that such an investigation fell well within the scope of the objects of the Society, organized a small Commission of two experts, who left England for the scene of the eruption eleven days only after the receipt of Mr. Chamberlain's letter; the expenses being met by a grant of £300 from the Government Grant Committee. Six weeks were spent in the Islands, including Martinique, by the Commission, which was successful in securing results of great scientific interest. A preliminary report was published at the time, and a full report has since appeared in the "Transactions."

Time forbids me to do more than mention the sucessive expeditions sent out by the Society, conjointly with the Royal Astronomical Society, for the observation of total solar eclipses; and the onerous work thrown upon the Society for several years in connection with the National Antarctic Expedition, undertaken jointly with the Royal Geographical Society, which has this year returned home crowned with success as regards the latter; but the Society's labours are not at an end, for the prolonged and responsible task of the discussion and publication of the scientific results of the Expedition is still before them.

In addition to the numerous undertakings, of which some examples have been given, in which the influence and work of the Society have been exercised for national or public objects, there are a number of other ways in which the Society makes its influence continually felt and of which the responsibilities are always with it. The Society is represented by the

President, as an *ex-officio* elector, in the election of eight scientific Professorships at the Oxford University, and one Professorship at Cambridge. The President is also *ex-officio* a trustee of the British Museum, and of the Hunterian Museum, and a Governor of the City and Guilds of London Institute. The Society has a voice, through a representative Fellow chosen by the Council, on the Governing bodies of the Imperial Institute, the Lister Institute of Preventive Medicine, Sir John Soane's Museum, Eton, Rugby, Harrow, Winchester, and four other Public schools, and the Advisory Board for Military Education. The Council of the Society are electors of four members of Lawes' Agricultural Trust, and are nominators of the members of the Meteorological Council. The Society is represented by the President and six of the Visitors on the Board of the Greenwich Observatory. One of the four sets of copies of the Standard Weights and Measures is held in custody by the Society. There is also a Committee for systematic work in Seismology.

To the Royal Society is entrusted the responsible task of administrating the annual Government Grant of £4000 for the purpose of scientific research, and a grant of £1000 in aid of the publication of scientific papers.

In addition to these permanent responsibilities, which are always with the Society, its advice and aid are sought from time to time both by the Government and by Scientific Institutions at home and abroad, in favour of independent objects of a more or less temporary character, of which, as examples, may be taken the recent action of the Society for the purpose of obtaining Government aid for the continuation through Egypt of the African Arc of Meridian, and for the intervention of the Government to assist in securing the fulfilment of the part undertaken by Great Britain in the International Astrographic Catalogue and Chart.

Upon the present Fellows falls the glorious inheritance of unbounded free labour ungrudgingly given during two centuries and a-half for the public service, as well as of the strenuous prosecution at the same time of the primary object of the Society, as set forth in the words of the Charters: "The promotion of Natural Knowledge." The successive generations of Fellows have unsparingly contributed of their time to the introduction and promotion, whenever the opportunity was afforded them, of scientific knowledge and methods into the management of public concerns by Departments of the Government. The financial independence of the Royal Society, neither receiving, nor wishing to accept State aid for its own private purposes, has enabled the Society to give advice and assistance which, both with the Government and with Parliament, have the weight and finality of a wholly disinterested opinion. I may quote here the words of a recent letter from

H.M. Treasury :—" Their Lordships have deemed themselves in the past very fortunate in being able to rely, in dealing with scientific questions, upon the aid of the Royal Society, which commands not only the confidence of the scientific world, but also of Parliament."

In the past the Royal Society has been not infrequently greatly hampered in giving its advice, by the knowledge that the funds absolutely needed for the carrying out of the matters in question in accordance with our present scientific knowledge would not be forthcoming. Though I am now speaking on my own responsibility, I am sure that the Society is with me, if I say that the expenditure by the Government on scientific research and scientific institutions, on which its commercial and industrial prosperity so largely depend, is wholly inadequate in view of the present state of international competition. I throw no blame on the individual members of the present or former Governments; they are necessarily the representatives of public opinion, and cannot go beyond it. The cause is deeper, it lies in the absence in the leaders of public opinion, and indeed throughout the more influential classes of society, of a sufficiently intelligent appreciation of the supreme importance of scientific knowledge and scientific methods in all industrial enterprises, and indeed in all national undertakings. The evidence of this grave state of the public mind is strikingly shown by the very small response that follows any appeal that is made for scientific objects in this country, in contrast with the large donations and liberal endowments from private benefaction for scientific purposes and scientific institutions which are always at once forthcoming in the United States. In my opinion, the scientific deadness of the nation is mainly due to the too exclusively mediæval and classical methods of our higher public schools, and can only be slowly removed by making in future the teaching of Science, not from text-books for passing an examination, but, as far as may be possible, from the study of the phenomena of Nature by direct observation and experiment, an integral and essential part of all education in this country.

I proceed to the award of the Medals.

Copley Medal.

The Copley Medal is awarded to Sir William Crookes, F.R.S., for his experimental researches in chemistry and physics, extending over more than fifty years. Ever since his discovery of the element thallium in the early days of spectrum analysis, he has been in the front rank as regards the refined application of that weapon of research in chemical investigation. Later, the discrepancies which he found in an attempt to improve weighings, by conducting the operation in high vacua, were tracked out by him to a repulsion arising from radiation, which was ultimately ascribed by theory to the action of the residual gas. This phenomenon, illustrated by the radiometer, opened up a new and fascinating chapter in the dynamical theory of rarefied gases, which the genius of Maxwell, O. Reynolds, and others has left still incomplete. The improvements in vacua embodied in the Crookes tube led him to a detailed and brilliant experimental analysis of the phenomena of the electric discharge across exhausted spaces; in this, backed by the authority of Stokes, he adduced, long ago, powerful cumulative evidence that the now familiar cathode rays, previously described by C. F. Varley, must consist of projected streams of some kind of material substance. His simple but minutely careful experiments on the progress of the ultimate falling off in the viscosity of rarefied gases, from the predicted constant value of Maxwell, at very high exhaustions, gave, in Stokes' hands, an exact account of the trend of this theoretically interesting phenomenon, which had already been approached in the investigations of Kundt and Warburg, using Maxwell's original method of vibrating discs.

These examples, not to mention recent work with radium, convey an idea of the acute observation, experimental skill, and persistent effort, which have enabled Sir William Crookes to enrich physical science in many departments.

Rumford Medal.

The Rumford Medal is awarded to Prof. Ernest Rutherford, F.R.S., on account of his researches on the properties of radio-active matter, in particular for his capital discovery of the active gaseous emanations emitted by such matter, and his detailed investigation of their transformations. The idea of radiations producing ionization, of the type originally discovered by Röntgen, and the idea of electrified particles, like the cathode rays of vacuum tubes, projected from radio-active bodies, had gradually become familiar through the work of a succession of recent investigators, when Rutherford's announcement of a very active substance, diffusing like a gas with a definite atomic mass, emitted by compounds of thorium, opened up yet another avenue of research with reference to these remarkable bodies. The precise interpretation of the new phenomena, so promptly perceived by Rutherford, was quickly verified for radium and other substances, by various observers, and is now universally accepted. The modes of degradation, and the enormous concomitant radio-activity, of these emanations, have been investigated mainly by Rutherford himself, with results embodied in his treatise on Radio-activity and his recent

Bakerian Lecture on the same subject. It perhaps still remains a task for the future to verify or revise the details of these remarkable transformations of material substances, resulting apparently in the appearance of chemical elements not before present; but, however that may issue, by the detection and description of radio-active emanations and their transformations, Prof. Rutherford has added an unexpected domain of transcendent theoretical interest to physical science.

Royal Medal.

A Royal Medal is awarded to Prof. W. Burnside, F.R.S., on the ground of the number, originality, and importance of his contributions to Mathematical Science. The section of our "Catalogue of Scientific Papers" for the period 1883–1900, enumerates fifty-three papers by Prof. Burnside, the first dated 1885, and the "International Catalogue of Scientific Literature" thirteen more. His mathematical work has consisted laregly of papers on the Theory of Groups, to which he has made most valuable additions. In 1897 he published a volume "On the Theory of Groups of Finite Order," which is a standard authority on that subject. Two recent papers on the same theory, published in 1903, may be specially mentioned. In one of these he succeeded in establishing by direct methods, distinguished by great conciseness of treatment, the important subsidiary theory of group-characteristics, which had been originally arrived at by very indirect and lengthy processes. In the other he proved quite shortly the important result that all groups of which the order is the product of powers of two primes are soluble.

Besides the treatise and papers relating to group theory, Prof. Burnside has published work on various branches of pure and applied mathematics. His work on automorphic functions dealt with an important and difficult special case which was not included in the theory of these functions as previously worked out. The paper on Green's function for a system of non-intersecting spheres was perhaps the first work by any writer in which the notions of automorphic functions and of the theory of groups were applied to a physical problem. He has also made important contributions to the Theory of Functions, Non-Euclidean Geometry, and the Theory of Waves on Liquids. His work is distinguished by great acuteness and power, as well as by unusual elegance and most admirable brevity.

Royal Medal.

The other Royal Medal is awarded to Col. David Bruce, F.R.S., who, since 1884, has been engaged in prosecuting to a successful issue researches into the causation of a number of important diseases affecting man and animals. When he went to Malta in 1884 the exact nature of the widely-prevalent "Malta," "Rock," or "Mediterranean" Fever was entirely unknown. After some years' work at the etiology of this disease, he discovered in 1887 the organism causing it, and succeeded in cultivating the *Micrococcus melitensis* outside the body. This discovery has been confirmed by many other workers, and is one of great importance from all points of view, and perhaps more especially as, thanks to it, Malta Fever can now be separated from other diseases, *e.g.*, typhoid, remittent, and malarious fevers, with which it had hitherto been confounded.

During the next few years he was engaged in researches of value on Cholera, and on methods of immunisation against this disease. He also carried out some work on the Leucocytes in the Blood, published in the "Proceedings of the Royal Society," 1894.

In 1894 he was requested by the Governor of Natal to investigate the supposed distinct diseases of "Nagana" and the Tsetse Fly disease. In the short time of two months he made the most important discovery that these two diseases were one and the same, and dependent upon the presence of a protozoan organism in the blood known as a Trypanosoma. Some six months later Bruce was enabled to return to Zululand, and remained there two years, studying the disease and making the discovery that the Tsetse Fly acted as the carrier of the organism which caused it. He was thus the first to show that an insect might carry a protozoan parasite that was pathogenic. This observation was made in 1895.

Bruce not only determined the nature and course of "Nagana," but in addition he studied the disease in a large number of domestic animals, and also observed the malady in a latent form in the wild animals of South Africa. Subsequent observers have found but little to add to Bruce's work on this subject.

In 1900, Bruce was ordered to join a Commission investigating the outbreak of Dysentery in the Army in South Africa, and a great part of the laboratory work performed by this Commission was carried out by him.

In 1903, Col. Bruce went, at the request of the Royal Society, to Uganda, to investigate further the nature of Sleeping Sickness. It was very largely, if not entirely, owing to him that the work of the Royal Society's Commission was brought to a successful issue. At the time when he arrived, a Trypanosoma had been observed by Castellani in a small number of cases of this disease; thanks to Bruce's energy and scientific insight, these observations were rapidly extended, and the most conclusive evidence obtained, that in all cases of the disease the Trypanosoma was present. He showed further that a certain Tsetse Fly, the *Glossina palpalis,* acted as the carrier of the Trypanosoma, and obtained evidence showing that the distribution of the disease and of the fly were strikingly similar.

Bruce has therefore been instrumental in discovering and establishing the exact nature and cause of three wide-spread diseases of man and of animals, and in two of these, Nagana and Malta Fever, he discovered the causal organism. In the third, Sleeping Sickness, he was not the first to see the organism, but he was quick to grasp and work out the discovery, and he made the interesting discovery of the carrier of the pathogenic organism, and thus discovered the mode of infection and of spread of the malady, matters of the highest importance as regards all measures directed to arrest the spreading of the disease. All this research work has been done whilst serving in the Royal Army Medical Corps, and engaged in the routine work of the Service.

Davy Medal.

The Davy Medal is awarded to Prof. W. H. Perkin, jun., F.R.S., for his masterly and fruitful researches in the domain of synthetic organic chemistry, on which he has been continuously engaged during the past twenty-five years.

Dr. Perkin's name is identified with the great advances which have been made during the past quarter of a century in our knowledge of the ring or cyclic compounds of carbon. Thus, in the year 1880, the cyclic carbon compounds known to chemists were chiefly restricted to the unsaturated groupings of six carbon atoms met with in benzene and its derivatives, whilst the number of compounds in which saturated carbon rings had been recognised was very limited, and it was indeed considered very doubtful whether compounds containing carbon rings with more or less than six atoms of carbon were capable of existence.

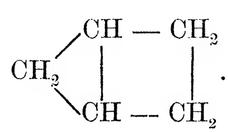
The starting point for Dr. Perkin's researches in this field of enquiry was his investigation of the behaviour of the di-halogen derivatives of various organic radicals with the sodium compounds of malonic, aceto-acetic, and benzoyl-acetic esters, which led to the synthesis of the cyclic polymethylene compounds up to those of hexamethylene, whilst heptamethylene derivatives were obtained by an adaptation of the well-known reduction of ketonic bodies leading to pinacones. The reactions thus introduced by Perkin are now classical, having proved themselves of the highest importance for synthetical purposes and having been instrumental in stimulating the further investigation of the cyclic compounds of carbon.

Dr. Perkin also extended the same methods to the synthetical formation of carbon rings of the aromatic series, obtaining by means of ingeniously designed reactions derivatives of hydrindonaphthene and tetrahydronaphthalene.

But whilst the above achievements depend mainly on happily conceived and brilliantly executed extensions of the malonic and aceto-acetic ester syntheses, Perkin has, by a remarkable development of the Frankland and Duppa reaction for the synthesis of hydroxyacids, been successful in building up the important camphoronic acid in such a manner as to place its constitution beyond doubt (1897).

Dr. Perkin has further devoted much attention to the important subject of the constitution of camphor, towards the elucidation of which he has contributed valuable experimental evidence embodied in a most important and elaborate paper, containing the results of many years' work in conjunction with numerous pupils, entitled "Sulphocamphylic acid and Isolauronolic acid, with remarks on the Constitution of Camphor and some of its derivates" (1898). Bearing on the same subject are later communications on camphoric acid and isocamphoronic acid.

About the year 1900, Perkin, in prosecuting his researches on the constitution of camphor compounds, succeeded in devising synthetical methods for the production of what he has termed "bridged rings," of which a simple example is furnished by the hydrocarbon dicyclopentane



The universal admiration of organic chemists has been called forth by these investigations; they reveal, indeed, a wonderful capacity for devising reactions which coerce carbon atoms to fall into the desired groupings.

Of other publications displaying not only extraordinary experimental skill but close reasoning and the power of interpreting results, mention may be made of Dr. Perkin's memorable researches on the constitution of dehydracetic acid, berberine, brasilin, and hæmatoxylin respectively.

During the present year (1904), Dr. Perkin has made perhaps the most remarkable addition to the long list of his achievements by successfully synthesising terpin, inactive terpineol, and dipentene, substances which had previously engaged the attention of some of the greatest masters of organic chemistry.

In conclusion it may be stated that Professor Perkin is not only the author of the above and numerous other important researches which are outside the scope of this brief summary, but that he has also created a school of research in organic chemistry, which stands in the very highest rank.

Darwin Medal.

The Darwin Medal is awarded to Mr. William Bateson, F.R.S., for his researches on heredity and variation.

Mr. Bateson began his scientific career as a morphologist, and distinguished himself by researches on the structure and development of Balanoglossus, which have had a far-reaching influence on morphological science, and which established to the satisfaction of most anatomists the affinity of the Enteropneusta to the Chordate phylum. Dissatisfied, however, with the methods of morphological research as a means of advancing the study of evolution, he set himself resolutely to the task of finding a new method of attacking the species problem. Recognising the fact that variation was the basis upon which the theory of evolution rested, he turned his attention to the study of that subject, and entered upon a series of researches which culminated in the publication in 1894 of his well-known work, entitled "Materials for the Study of Variation, etc." This book broke new ground. Not only was it the first systematic work which had been published on variation, and, with the exception of Darwin's "Variation of Animals and Plants under Domestication," the only extensive work dealing with it; but it was the first serious attempt to establish the importance of the principle of discontinuity in variation in its fundamental bearing upon the problem of evolution, a principle which he constantly and successfully urged when the weight of authority was against it. In this work he collected and systematised a great number of examples of discontinuous variation, and by his broad and masterly handling of them he paved the way for those remarkable advances in the study of heredity which have taken place in the last few years, and to which he has himself so largely contributed. He was the first in this country to recognise the importance of the work of Mendel, which, published in 1864, and for a long time completely overlooked by naturalists, contained a clue to the labyrinth of facts which had resulted from the labours of his predecessors. He has brought these results prominently forward in England in his important reports to the Evolution Committee of the Royal Society, and in papers before the Royal and other Societies, and also before horticulturists and breeders of animals. He has gathered about him a distinguished body of workers, and has devoted himself with great energy and with all his available resources to following out lines of work similar to those of Mendel. The result has been the supporting of Mendel's conclusions and the bringing to light of a much wider range of facts in general harmony with them. It is not too much to say that Mr. Bateson has developed a school of research to which many biologists are now looking as the source from which the next great advance in our knowledge of organic evolution will come.

Sylvester Medal.

The Sylvester Medal is awarded to Georg Cantor, Professor in the University of Halle, on account of his researches in Pure Mathematics. His work shows originality of the highest order, and is of the most far-reaching importance. He has not only created a new field of mathematical investigation, but his ideas, in their application to analysis, and in some measure to geometry, furnish a weapon of the utmost power and precision for dealing with the foundations of mathematics, and for formulating the necessary limitations to which many results of mathematics are subject.

In 1870 he succeeded in solving a question which was then attracting much attention—the question of the uniqueness of the representation of a function by Fournier's series. The extension of the result to cases in which the convergence of the series fails, at an infinite number of suitably distributed points, led him to construct a theory of irrational numbers, which has since become classical. From the same starting point he developed, in a series of masterly memoirs, an entirely new branch of mathematics—the Theory of Sets of Points.

Having established the fundamental distinction between those aggregates which can be counted and those which cannot, Cantor showed that the aggregates of all rational numbers and of all algebraic numbers belong to the former class, and that the arithmetic continuum belongs to the latter class, and further, that the continuum of any number of dimensions can be represented point for point by the linear continuum. Proceeding with these researches he introduced and developed his theory of "transfinite" ordinal and cardinal numbers, thus creating an Arithmetic of the Infinite. His later abstract theory of the order-types of aggregates, in connection with which he has given a purely ordinal theory of the arithmetic continuum, has opened up a field of research of the greatest interest and importance.

HUGHES MEDAL.

The Hughes Medal is awarded to Sir Joseph Wilson Swan, F.R.S., for his invention of the incandescent electric lamp, and his other inventions and improvements in the practical applications of electricity. Not as directly included in the award, should be mentioned his inventions in dry-plate photography, which have so much increased our powers of experimental investigation.

The Boring of the Simplon Tunnel, and the Distribution of Temperature that was encountered.

By FRANCIS FOX, M.Inst.C.E.

(Communicated by C. V. Boys, F.R.S. Received January 6,—Read January 26, 1905.)

The construction of this great tunnel under the Swiss Alps, between Brigue in Switzerland in the valley of the Rhone, and Iselle in that of the Diveria in Italy, a distance of 19,730 metres, has been carried on upon such highly scientific lines, and has revealed such extraordinary results, that it has been thought desirable to submit them in the form of a communication to the Royal Society. They are likely to prove of considerable value and importance as regards the thermal condition of the region underlying that portion of the surface of the earth.

It is not necessary here to refer to the splendid organisation of the enterprise, nor to the humane arrangements for the welfare of the men; but the rapidity with which the drilling has been effected, and the advance-headings driven forward, as also the excellent ventilation provided, have enabled much more trustworthy results to be obtained than would otherwise have been the case.

The Brandt hydraulic drill, by which a daily advance of 5·48 metres (18 feet) for months together, has been attained, has been described elsewhere; but the fact of its rapid advance enables the temperature of the rocks to be recorded before the lapse of a considerable time during which the rocks would be cooling. On the other hand, the very excellent system